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(54) **DISPLAY ASSEMBLIES FOR PROVIDING COMPRESSIVE FORCES AT ELECTRONIC DISPLAY LAYERS**

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(58) **Field of Classification Search**

None

See application file for complete search history.

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(57) **ABSTRACT**

A display assembly includes a structural framework, a cover forward of an electronic display layer, and an illumination device rearward of the electronic display layer. A rear passageway is provided between a rear portion of the structural framework and a rear surface of the illumination device and is in fluid communication with a front passageway between a rear surface of the cover and a forward surface of the electronic display layer and an illumination device passageway between a rear surface of the electronic display layer and a front surface of the illumination device. A closed loop fan unit adjacent to an entrance to the front passageway and the illumination device passageway creates flows of circulating gas therethrough when activated.

22 Claims, 12 Drawing Sheets

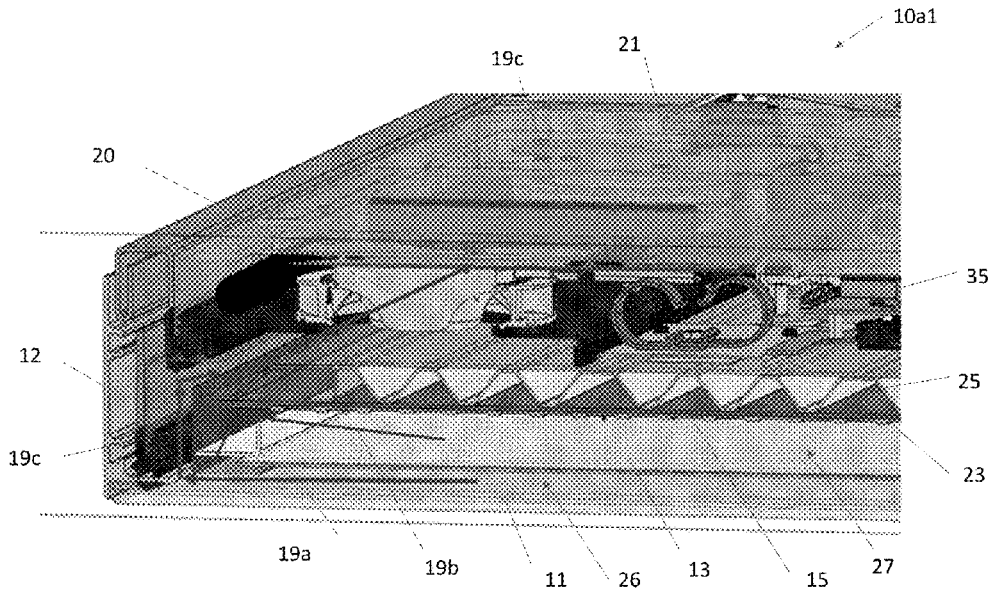

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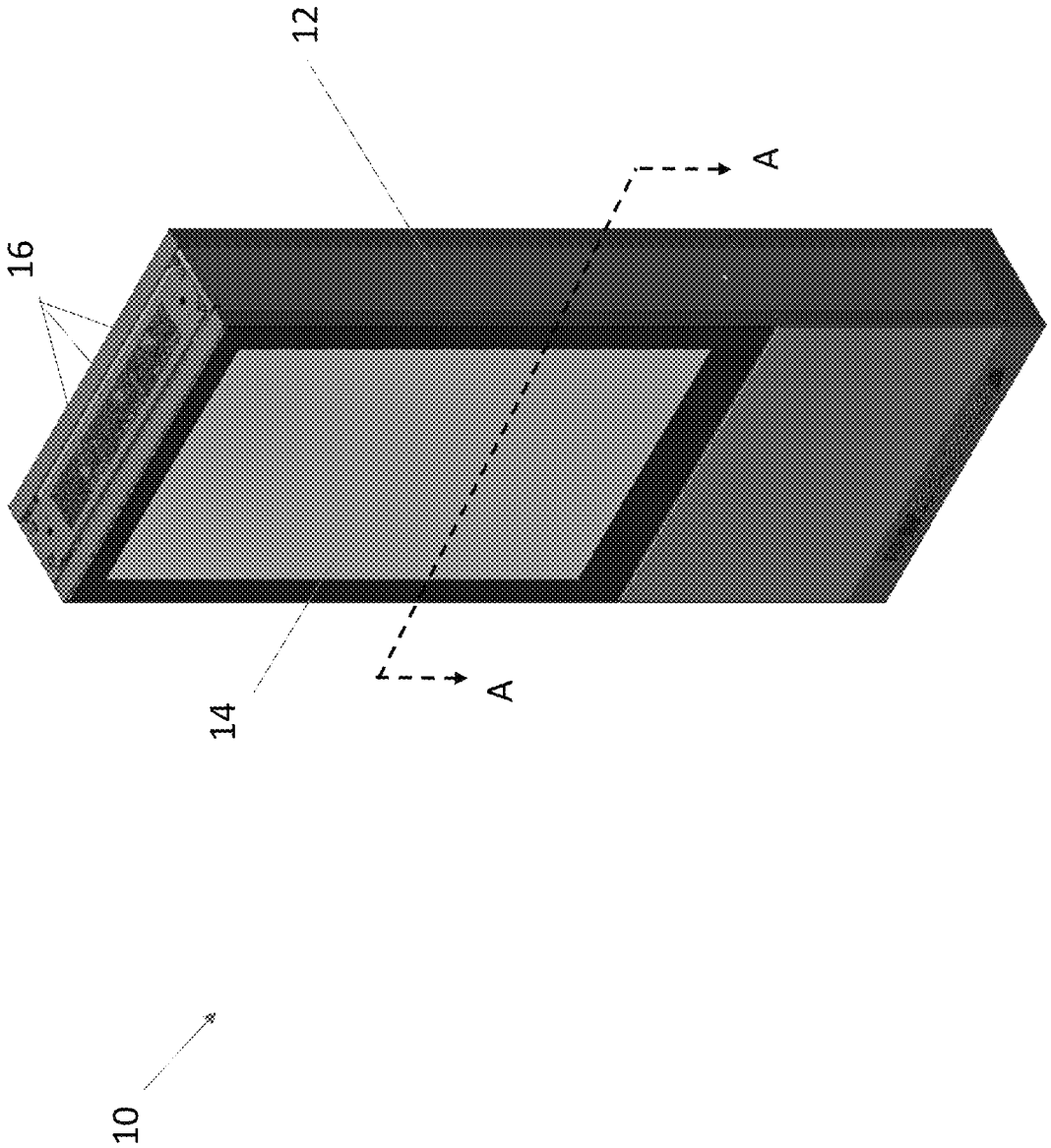
Figure 1



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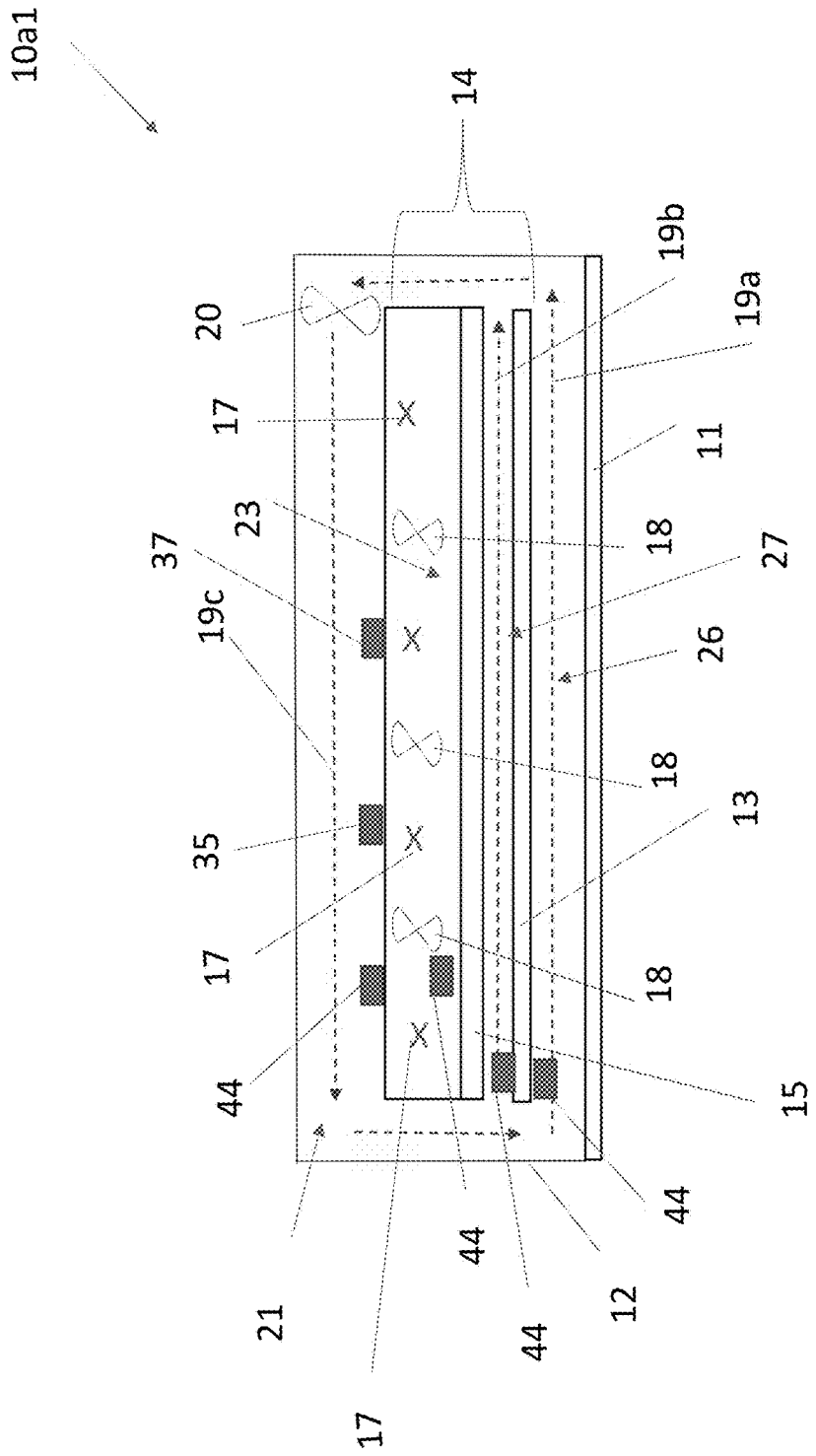
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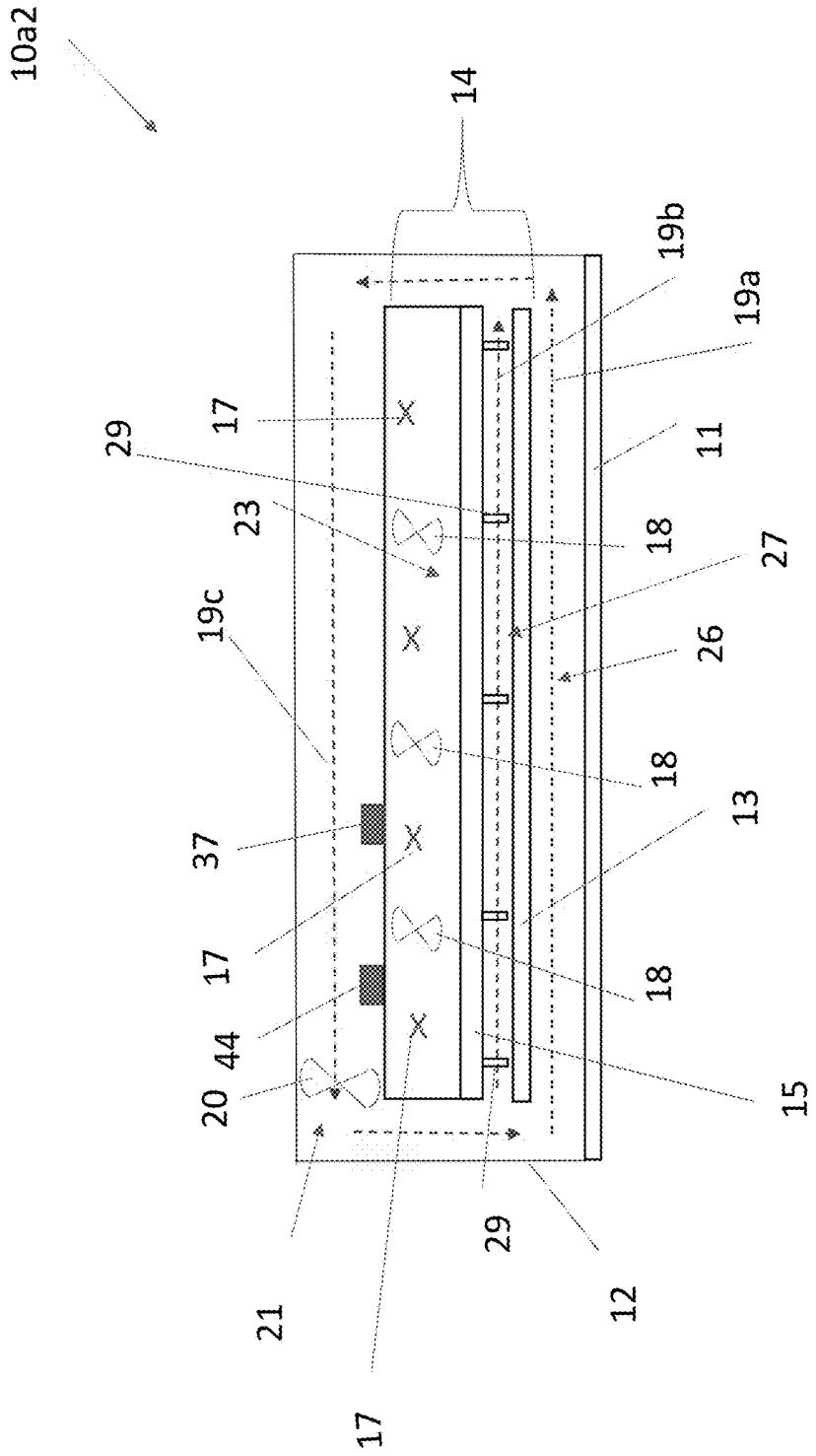
Figure 2B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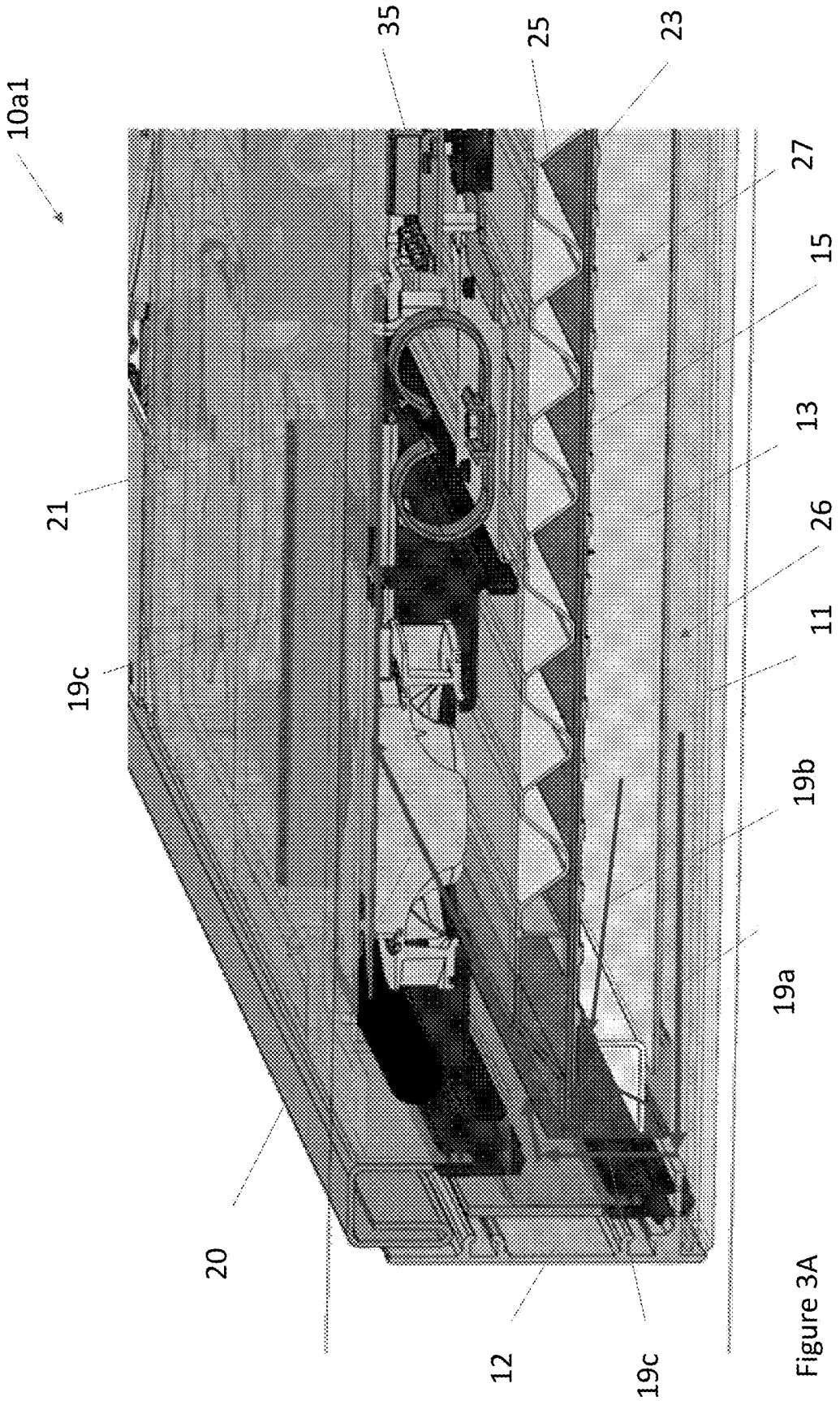

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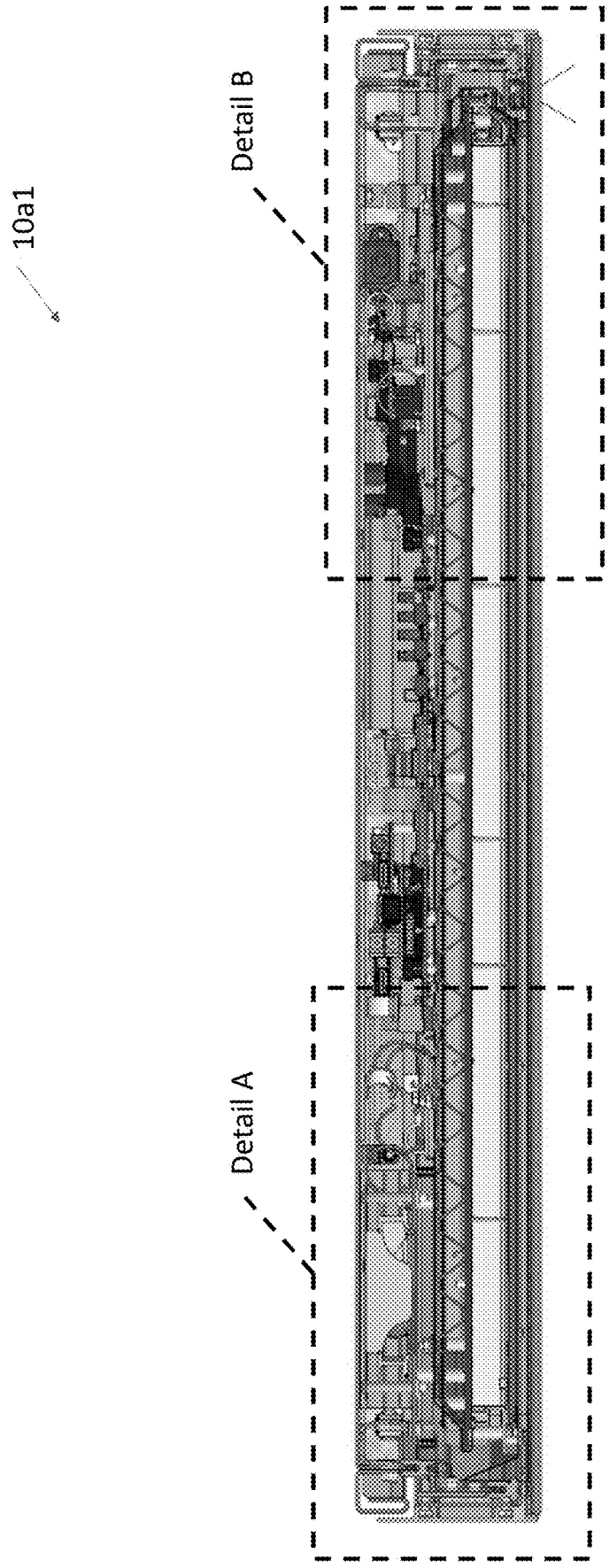

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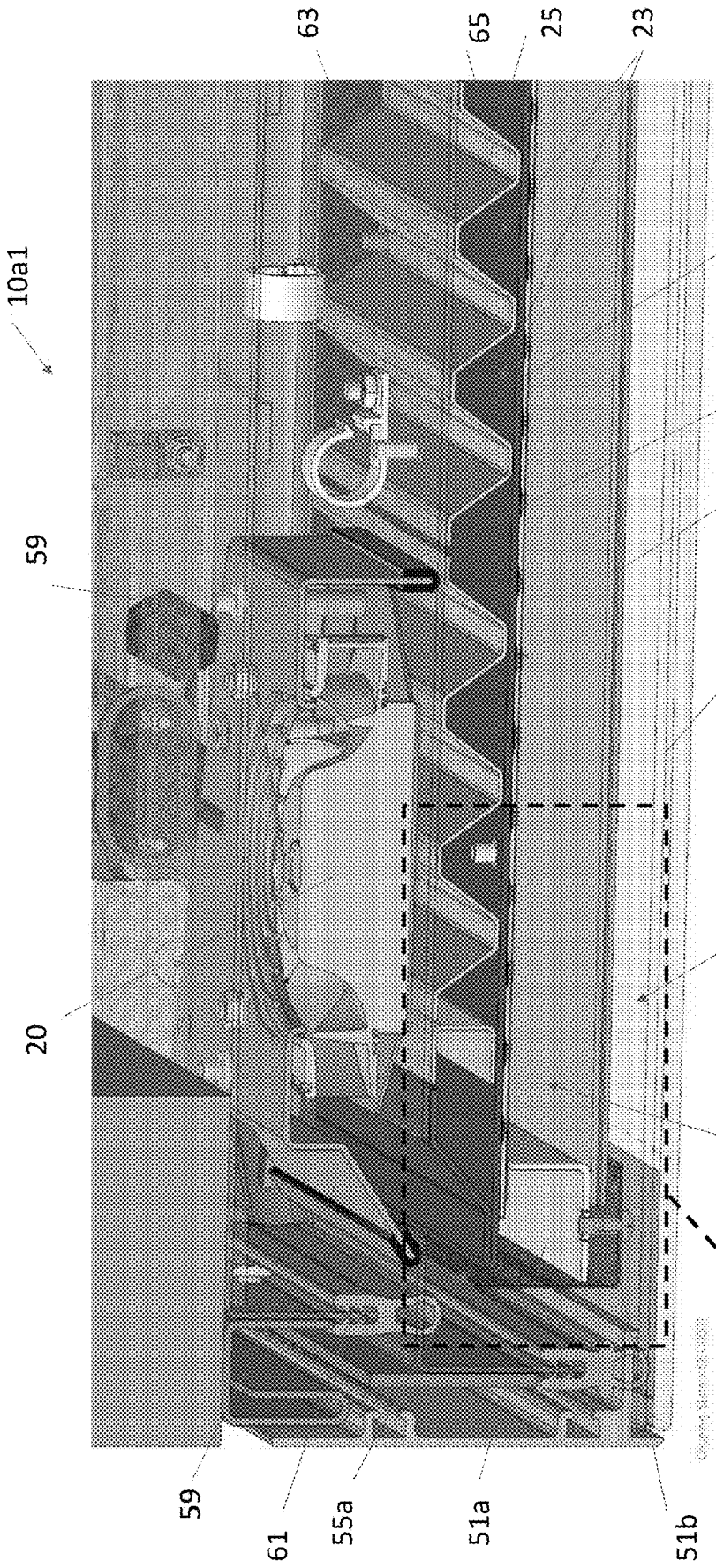

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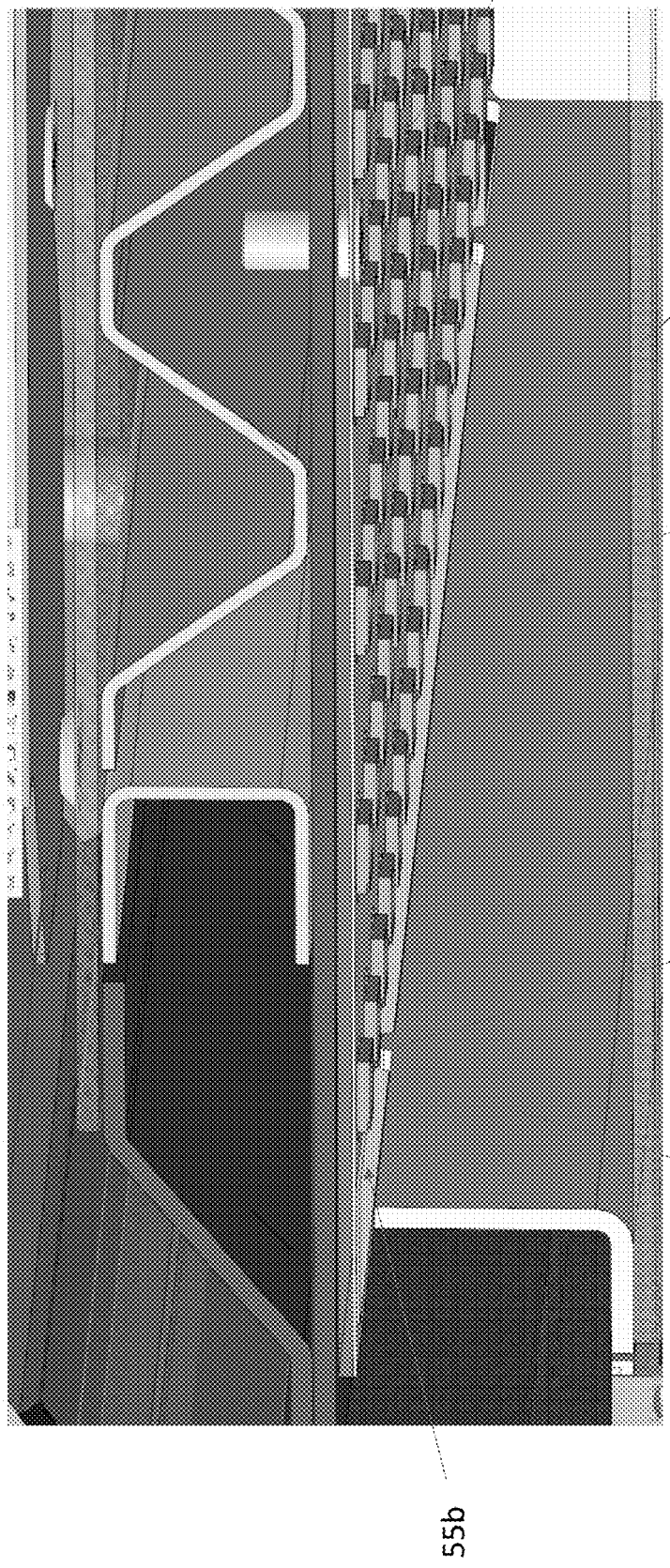

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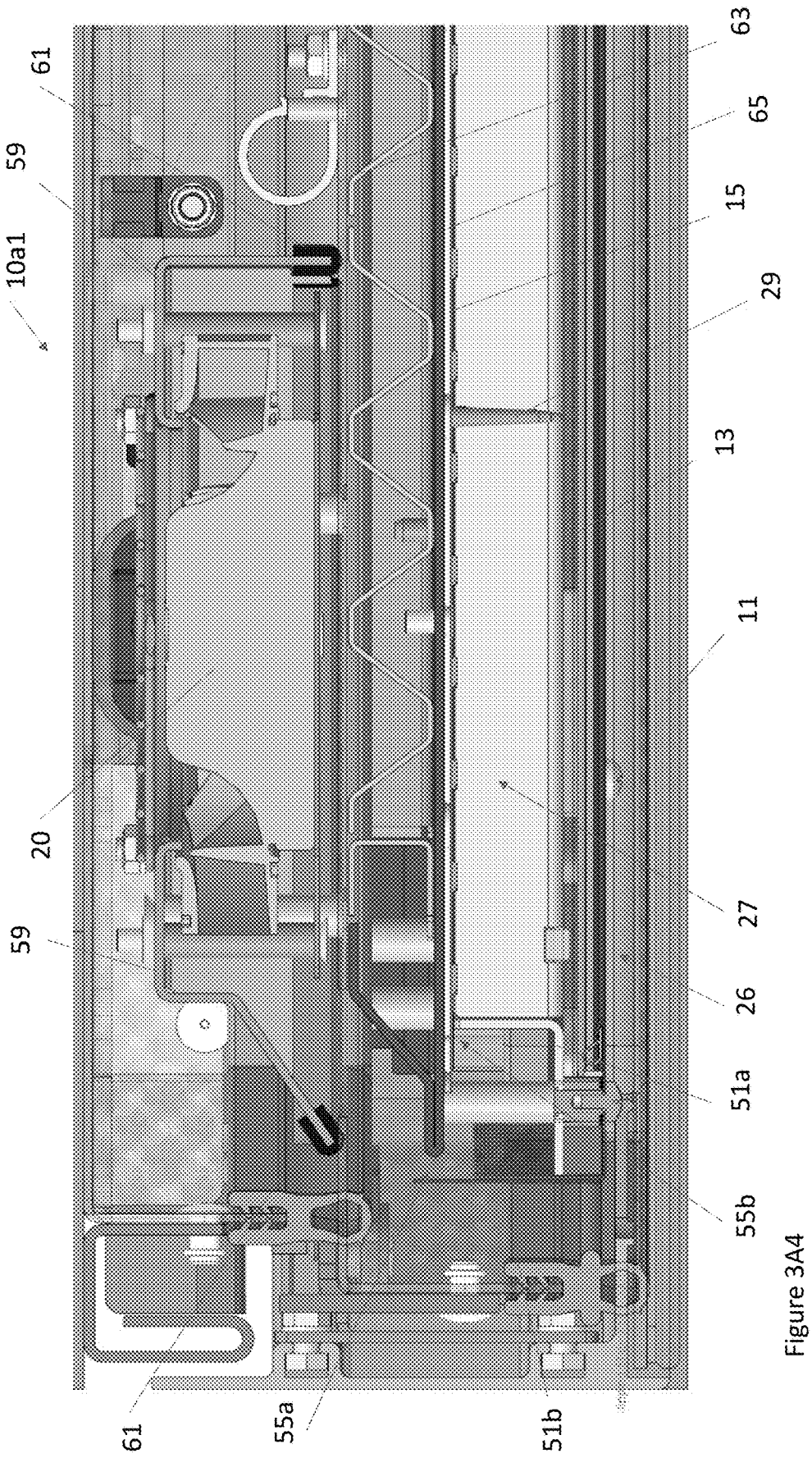

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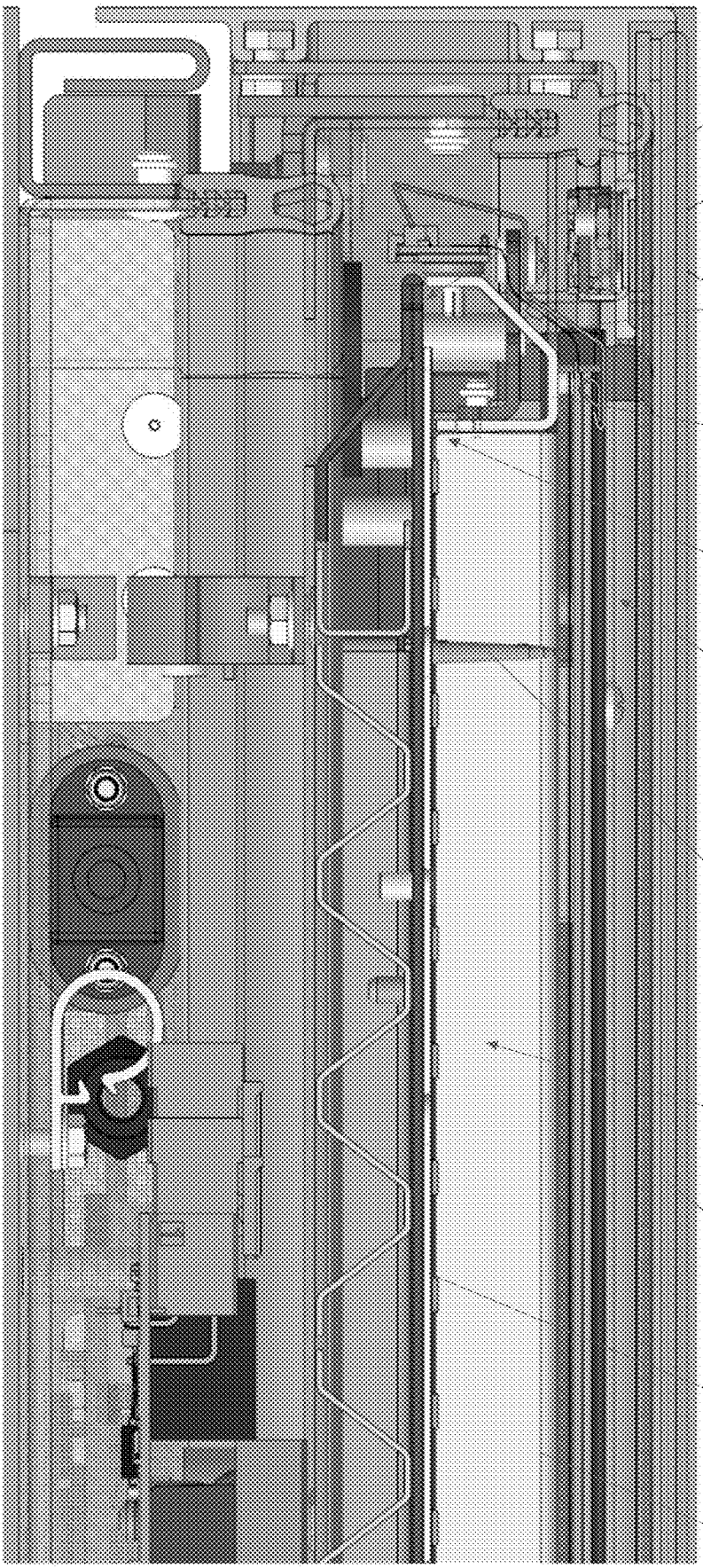

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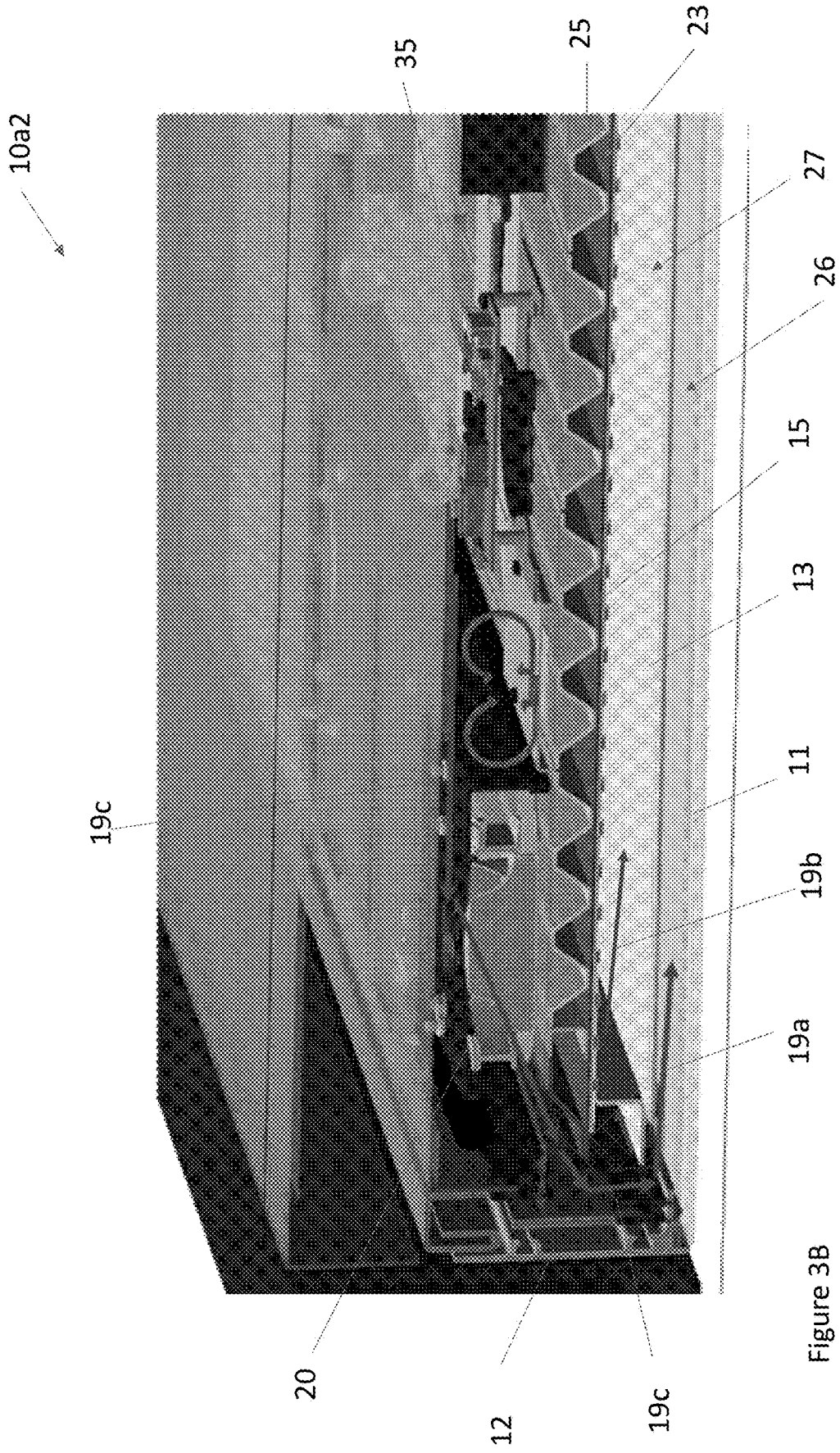

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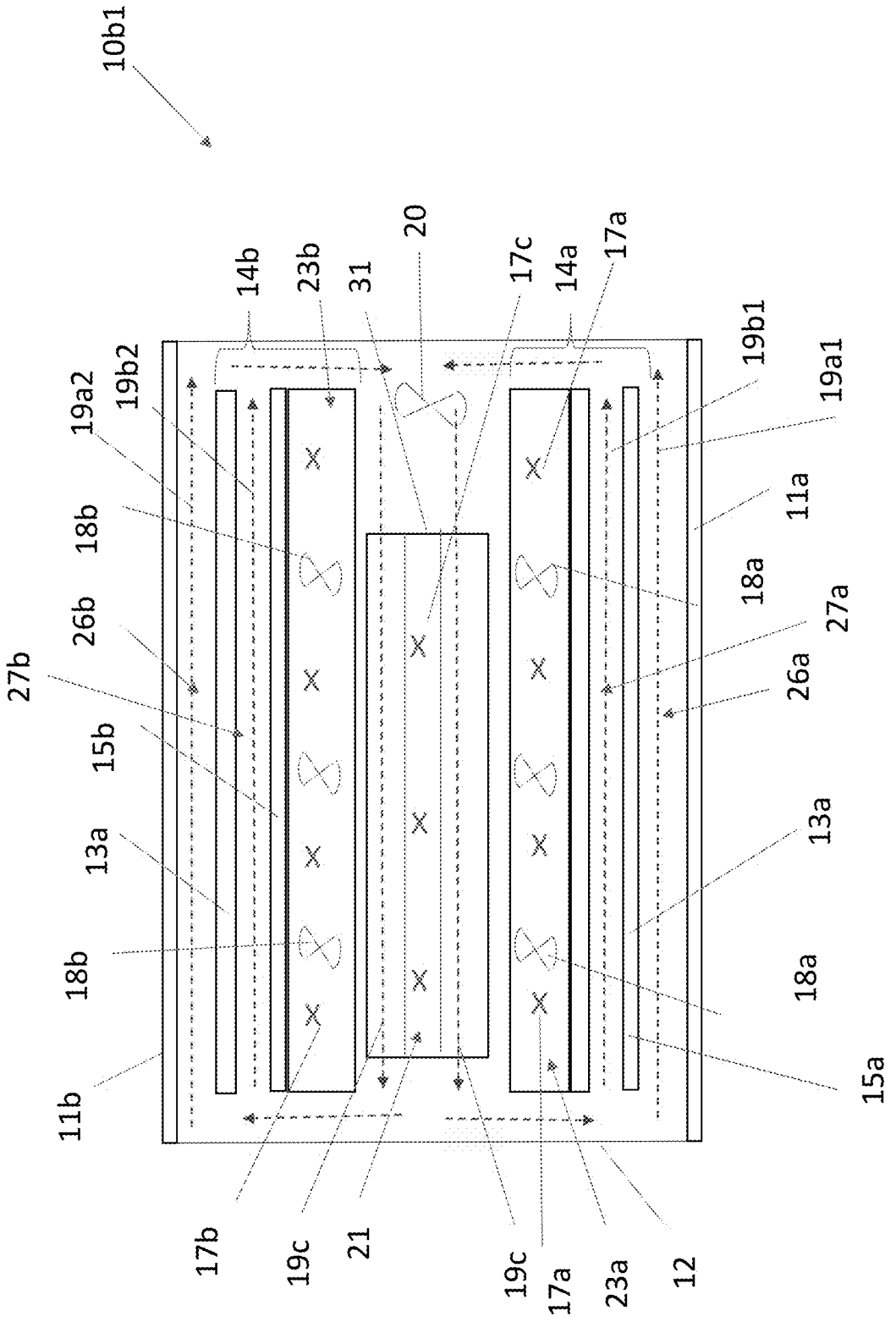
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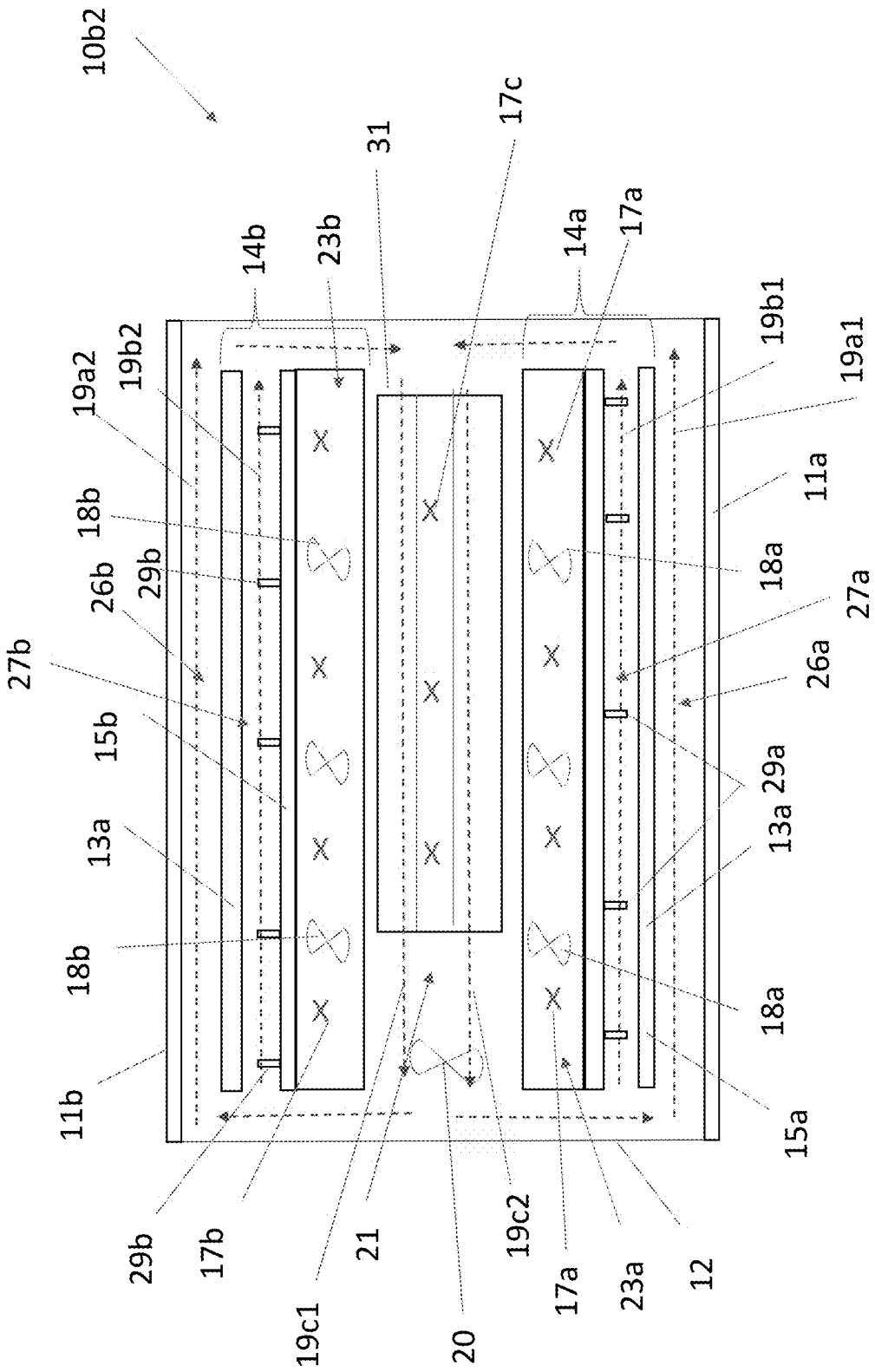
Figure 4A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17b
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23a
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Figure 4B

DISPLAY ASSEMBLIES FOR PROVIDING COMPRESSIVE FORCES AT ELECTRONIC DISPLAY LAYERS

CROSS-REFERENCE TO RELATED APPLICATIONS

This application makes no priority claim.

TECHNICAL FIELD

Exemplary embodiments relate generally to display assemblies configured to provide compressive forces at on one or more electronic display layers, such as on one or both sides of electronic display layers.

BACKGROUND AND SUMMARY OF THE INVENTION

Certain electronic display layers, such as those comprising liquid crystals, are relatively thin. These electronic display layers often span a relatively large area. In some cases, these electronic display layers may only be supported at a perimeter. This may subject the electronic display layers to distortion by external forces, such as air pressure. Such distortions may result in various optical or other performance issues. These issues become particularly problematic when relatively large displays are utilized because relatively small air pressures experienced over a large area result in application of significant net forces. It is known to provide air on either side of an electronic display layer to create a pressure differential which reduces or eliminates bowing of the electronic display layer, such as is shown and/or described in U.S. Pat. No. 10,398,066 issued Aug. 27, 2019.

It is known to provide various optical layers at the electronics display layer and/or a cover for the same including, but not limited to, polarizing films, anti-reflective coatings, combinations thereof, or the like to improve optical qualities of displayed images. In certain cases, it may be desirable to provide compressive forces on one or both sides of an electronic display layer to prevent or eliminate cell breach of the electronic display layer and/or mechanical separation of optical layers. What is needed is a display assembly which provides compressive forces on one or both sides of an electronic display layer.

Display assemblies which provide compressive forces on one or both sides of an electronic display layer, and methods related to the same, are provided. The display assemblies may include one or more closed loop airflow pathways. At least one of the closed loop airflow pathways may include a front passageway which extends between a cover for the electronic display layer and the electronic display layer itself as well as an illumination device passageway which extends between the electronic display layer and an illumination device for the electronic display layer. A rear passageway extending behind the illumination device may be in fluid communication with both the front passageway and the illumination device passageway to complete the closed loop airflow pathway, which may encircle the illumination device and/or the electronic display layer.

A closed loop fan unit may be positioned adjacent to an entrance to the front passageway and the illumination device passageway in exemplary embodiments. The closed loop fan unit may be configured to push circulating gas through the front passageway and illumination device passageway when activated. The closed loop fan unit may be configured to generate a relatively high-pressure area at a first side of the closed loop fan unit facing the entrance to the front passageway and illumination device passageway such that such a relatively high-pressure flow is created within at least a portion of the front passageway and illumination device passageway when activated. The closed loop fan unit may be configured to generate a relatively low-pressure area at an opposing side of the closed loop fan unit facing the rear passageway when activated such that a relatively low-pressure flow is created within the rear passageway when activated. When operated, the closed loop fan unit may be configured to generate a pressure differential on one or both sides of the electronic display layer such that a pressure of a flow of the circulating gas in the front passageway is higher than a pressure of a flow of the circulating gas in the illumination device passageway. This may result in inward directed net forces at the electronic display layer which forces the electronic display layer rearward towards the illumination device, thereby reducing or eliminating bowing of the electronic display layer. This arrangement may be configured to create a positive pressure relative to ambient at one or both of a front and/or rear surface of the electronic display layer (e.g., in the front passageway and/or the illumination device passageway) so as to provide compressive forces at the front and/or rear side of the electronic display layer. This may prevent cell breach in the electronic display layer and/or mechanical separation of the optical layers from either or both of the electronic display layer and the cover. Optical spikes may be provided between the electronic display layer and the illumination device, such as within the illumination device passageway, to limit or prevent rearward movement of the electronic display layer towards the illumination device to prevent visual distortions.

In other exemplary embodiments, the closed loop fan unit may be positioned at an exit of the front passageway and illumination device passageway. The closed loop fan unit, in such embodiments, may be configured to draw circulating gas through the front passageway and the illumination device passageway. The closed loop fan unit, in such embodiments, may be configured to generate a relatively low-pressure area at the exit to the front passageway and the illumination device passageway and/or a relatively high-pressure area at an opposing side of the closed loop fan unit oriented towards the rear passageway when activated. In such embodiments, the closed loop fan unit may be configured to create a negative pressure relative to ambient within some or all of the front passageway and/or illumination device passageway such that a pressure of a flow of the circulating gas in the front passageway is higher than a pressure of a flow of the circulating gas in the illumination device passageway, even if one or both are negative relative to pressure of ambient air. Such an arrangement may permit creation of differential pressures sufficient to reduce or eliminate bowing of the electronic display layer.

The display assemblies may include multiple electronic display layers in exemplary embodiments. Where multiple electronic display layers are utilized, a single rear passageway may be common to at least two of the multiple electronic display layers. The display assemblies may include one or more open loop airflow pathways for ambient air. One or more open loop fan units may be provided for forcing ambient air through the open loop airflow pathways when operated. A structural framework may be used to secure and/or house the various components of the display assemblies. The closed loop fan units may be mounted within the rear passageways, in exemplary embodiments. Electronic components for operating the electronic display layers may be provided within the rear passageway.

Pressure sensors may be provided to monitor the differential pressure created, pressures of circulating gas within one or both of the front passageway and illumination device passageway and/or pressures of ambient air. Such sensors may be in electronic communication with one or more controllers. Operation of the closed loop fan units and/or open loop fan units may be adjusted, such as by the controllers, in response to readings from the sensors. For example, speed or duration of operation of the closed loop fan units may be adjusted to maintain the desired pressure differential and/or positive pressure relative to ambient within one or both of the front passageway and/or illumination device passageway.

Further features and advantages of the systems and methods disclosed herein, as well as the structure and operation of various aspects of the present disclosure, are described in detail below with reference to the accompanying figures.

BRIEF DESCRIPTION OF THE DRAWINGS

In addition to the features mentioned above, other aspects of the present invention will be readily apparent from the following descriptions of the drawings and exemplary embodiments, wherein like reference numerals across the several views refer to identical or equivalent features, and wherein:

FIG. **1** is a perspective view of an exemplary display assembly indicating section lines A-A;

FIG. **2**A is a top sectional view of an exemplary embodiment of the display assembly of FIG. **1** taken along section line A-A;

FIG. **2**B is a top sectional view of another exemplary embodiment of the display assembly of FIG. **1** taken along section line A-A;

FIG. **3**A is a perspective sectional view of an exemplary embodiment of the display assembly of FIG. **1** taken along section line A-A;

FIG. **3A1** is a top sectional view of the display assembly of FIG. **3**A;

FIG. **3A2** is a detailed perspective view of detail A of FIG. **3A1**;

FIG. **3A3** is a detailed perspective view of detail C of FIG. **3A2**;

FIG. **3A4** is a detailed top sectional view of detail A of FIG. **3A1**;

FIG. **3A5** is a detailed top sectional view of detail B of FIG. **3A1**;

FIG. **3**B is a perspective sectional view of another exemplary embodiment of the display assembly of FIG. **1** taken along section line A-A;

FIG. **4**A is a top sectional view of the display assembly of another exemplary embodiment of the display assembly of FIG. **1** taken along section line A-A; and

FIG. **4**B is a top sectional view of the display assembly of another exemplary embodiment of the display assembly of FIG. **1** taken along section line A-A.

DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENT(S)

Various embodiments of the present invention will now be described in detail with reference to the accompanying drawings. In the following description, specific details such as detailed configuration and components are merely provided to assist the overall understanding of these embodiments of the present invention. Therefore, it should be apparent to those skilled in the art that various changes and modifications of the embodiments described herein can be made without departing from the scope and spirit of the present invention. In addition, descriptions of well-known functions and constructions are omitted for clarity and conciseness.

Embodiments of the invention are described herein with reference to illustrations of idealized embodiments (and intermediate structures) of the invention. As such, variations from the shapes of the illustrations as a result, for example, of manufacturing techniques and/or tolerances, are to be expected. Thus, embodiments of the invention should not be construed as limited to the particular shapes of regions illustrated herein but are to include deviations in shapes that result, for example, from manufacturing.

FIG. **1** is a perspective view of an exemplary electronic display assembly (hereinafter also a "unit") **10** in accordance with the present invention. The unit **10** may include a structural framework **12**. The structural framework **12** may be configured for mounting to a ground surface, such as a sidewalk or street, mounting to a wall or other surface, incorporation into street furniture (e.g., phone booths, bus shelters, benches, railings, combinations thereof, or the like), combinations thereof, or the like. The structural framework **12** may comprise one or more members, panels, cladding, panels, housings, combinations thereof, or the like.

The units **10** may comprise one or more electronic display subassemblies **14**. Some or all of the electronic display subassemblies **14** may be attached to the structural framework **12** in a moveable manner, though such is not required. For example, the electronic display subassemblies **14** may be attached to the structural framework in a hinged manner to permit selective movement between a closed position whereby certain parts of the units **10** are fully or partially sealed, and an open position whereby certain parts of the interior of the unit **10** are exposed for access.

One or more intakes and exhausts **16** may be provided at the units **10** for ingesting and exhausting ambient air.

FIG. **2**A through FIG. **4**B illustrate various exemplary embodiments of airflow pathways within the units **10**. FIGS. **2**A-**3**B illustrate exemplary units **10***a***1**, **10***a***2** with a single electronic display subassembly **14**. FIGS. **4**A-**4**B illustrate exemplary units **10***b***1**, **10***b***2** with two electronic display subassemblies **14***a*, **14***b* placed in a back-to-back arrangement. Any number of electronic display subassemblies **14** may be utilized in any arrangement with the structural framework **12**. Similar or the same components used in conjunction with units **10** having multiple electronic display subassemblies **14** may use the same numbering with the addition of an "a", "b" and/or "1", "2", etc. (e.g., **14** to **14***a*, **14***b*, **19***a* to **19***a***1**, **19***a***2**). Any features or arrangements shown and/or described with respect to any of the embodiments of the units **10***a***1**, **10***a***2**, **10***b***1**, **10***b***2** (sometimes referred to collectively as "unit **10**" or "units **10**" herein) may be used with any other embodiment of the units **10**.

Each electronic display subassembly **14** may comprise an illumination device **15**. In exemplary embodiments, the illumination device **15** may comprise a number of lighting elements, such as LEDs, provided at a substrate, such as a printed circuit board. Each electronic display subassembly **14** may comprise an electronic display layer **13**. The electronic display layer **13** may comprise a layer of liquid crystals, such as for a liquid crystal display, though any type or kind of electronic display may be utilized. In exemplary embodiments, the illumination device **15** may be provided rearward of the electronic display layer **13** to serve as a direct backlight. In other exemplary embodiments, the illumination device **15** may comprise one or more diffusive

and/or transmissive layers and the substrate and/or lighting elements may be positioned about the edge of the electronic display layer **13** to provide edge lighting to the same.

The electronic display layer **13** and/or illumination device **15** may be positioned rearward of a cover **11**. The cover **11** may comprise one or more layers of a transparent or translucent material(s). In exemplary embodiments, each cover **11** may comprise two layers bonded with an optically clear adhesive, which may provide increased impact protection. One or more polarizers, anti-reflective materials, combinations thereof, or the like may be disposed on some or all of the cover **11** as a coating, film, layer, combinations thereof, or the like. The cover **11** may form part of the electronic display subassembly **14** or may be separate therefrom. The cover **11** and the structural framework **12** may together substantially enclose the units **10**, such as with intakes/exhausts **16** exempted, when the subassemblies **14** are placed in a closed position. The cover **11** may be configured to move with the electronic display subassembly **14**, may be configured for independent movement, and/or may be fixed to the structural framework **12**. Each of the electronic display subassemblies **14** may be connected to the structural framework **12** in a hinged or otherwise movable manner, though such is not required.

A single or multiple such electronic display subassemblies **14** may be provided at a single unit **10**, such as, but not limited to, in a back-to-back arrangement. The electronic display subassemblies **14** may be of the same or different type and may comprise the same or different components. The electronic display subassemblies **14** may be provided in any arrangement such as portrait or landscape.

The intakes and/or exhausts **16** may be fluidly connected to one or more open loop airflow pathways **23** within the units **10**. A respective one of the open loop airflow pathways **23***a*, **23***b* may extend through a respective one of the electronic display subassemblies **14***a*, **14***b* in exemplary embodiments such that an open loop airflow pathway **34** is provided for each one of the electronic display subassemblies **14**, which may be entirely separate, or separated for a distance and rejoined. For example, without limitation, the open loop airflow pathways **23** may extend behind and along at least a portion of the illumination devices **15** for the electronic display layer **13** for accepting flows **17***a*, **17***b* of ambient air. The open loop airflow pathways **23** may comprise one or more corrugated layers **25** in exemplary embodiments.

One or more closed loop airflow pathways may be provided within the units **10**. In exemplary embodiments, such closed loop airflow pathways may comprise at least a front passageway **26**, which may extend between the cover **11** and the electronic display layer **13**. Such closed loop airflow pathways may comprise a rear passageway **21**, which may extend behind the electronic display subassembly **14**, and/or behind the electronic display layer **13**. Such closed loop airflow pathways may extend entirely within the unit **10**, such as within outer boundaries of the structural framework **12**. Where multiple electronic display subassemblies **14***a*, **14***b* are utilized, the rear passageway **21** may be common to at least two of the electronic display subassemblies **14***a*, **14***b*, though such is not required. A heat exchanger **31** may be located within the rear passageway **21**, though such is not required. The heat exchanger **31** may comprise a multilayer heat exchanger configured to accommodate a common flow **19***c* of the circulating gas through at least some of the layers as well as one or more flows **17***c* of ambient air through at least some other ones of the layers.

Various electronic components **35** for operating the unit **10** may be provided within the rear passageway **21**. The electronic components **35** may include, for example, without limitation, video players, power supplies, processors, electronic storage devices, controllers **37**, sensors **44**, combinations thereof, or the like. Any number, type, and/or kind of components **35** may be utilized.

An illumination device passageway **27***a*, **27***b* may extend between each of the electronic display layers **13***a*, **13***b* and the respective illumination devices **15***a*, **15***b*. A flow of circulating gas **19***c* within the rear passageway **21** may be separated such that a first portion **19***a* flows through the front passageway **26** and a second portion **19***b* flows through the illumination device passageway **27**. The flows **19***a*, **19***b* may be recombined, such as in the rear passageway **21**.

One or more open loop fan units **18** may be provided. The same of different open loop fan units **18** may be associated with each of the open loop airflow pathways **23**. The open loop fan units **18** may be configured to ingest ambient air **17** into the units **10**, exhaust ambient air **17** from the assembly **10**, and/or move ingested ambient air **17** through the one or more open loop airflow pathways **23** when activated. Multiple open loop fan units **18***a*, **18***b* may be used where multiple electronic display subassemblies **14***a*, **14***b* are utilized, for example, or such open loop fan units **18** may be common to multiple ones of the electronic display subassemblies **14** of such units **10**.

One or more closed loop fan units **20** may be provided. Each closed loop fan unit **20** may comprise one or more fans or the same of different type. The same or different closed loop fan units **20** may be associated with each of the closed loop airflow pathways. The closed loop fan units **20** may be configured to move circulating gas through said one or more closed loop airflow pathways when activated. The closed and open loop fan units **20**, **18** may comprise axial fans, centrifugal fans, combinations thereof, or the like. Any number or type of fan units **20**, **18** may be used at any location in the units **10**, and may be provided in banks or sets. The open loop airflow pathways **23** may be separate from the closed loop airflow pathways, though a complete (e.g., gas impermeable) separation is not necessarily required. The same closed loop fan units **20** may be used to move circulating gas through the front passageways **26***a*, **26***b* and/or illumination device passageways **27***a*, **27***b* of multiple electronic display subassemblies **14***a*, **14***b* where such multiple electronic display subassemblies **14***a*, **14***b* are provided for a unit **10**, though such is not required.

The unit **10** may comprise a controller **37** and/or one or more sensors **44**. The sensors **44** may comprise, for example, without limitation, temperature sensors, fan speed sensors, airflow sensors, humidity sensors, relative humidity sensors, air pressure sensors, differential pressure sensors, location sensors, moisture sensors, combinations thereof, or the like. Any type, kind, or number of sensors **44** may be utilized at any number of locations within the units **10**. In exemplary embodiments, at least certain of the sensors **44** may comprise tubes or other fluid passageways to connect the sensor (s) **44** to other parts of the units **10** and/or the ambient environment. This may provide for flexibility in placement and design. Any type, kind, or number of controllers **31** may be utilized at any number of locations within the units **10**. Such sensors **44** and/or controller **37** are not necessarily required, and may be omitted from view of certain embodiments provided herein to more clearly illustrate other components. However, such sensors **44** and/or controller **37** may

be utilized in the same or similar arrangements in such embodiments, even where not expressly provided in the figures.

The one or more closed loop fan units **20** may be configured to create a pressure differential. For example, an intake side of each closed loop fan unit **20** may be configured to generate a relatively low-pressure area or flow and an exhaust side may be configured to generate a relatively high-pressure area or flow. As illustrated with particular regard to FIGS. **2**A, **3**A-**3**A**5**, and **4**A, in exemplary embodiments, one or more of the closed loop fan units **20** may be positioned adjacent to an exhaust for the front passageway **26** and/or the illumination device passageway **27**. For example, without limitation, the closed loop fan units **20** in such embodiments may be positioned at a portion of the rear passageway **21** adjacent to an exit from one or both of the front passageway **26** and the illumination device passageway **27** for generating the flows **19***a* and/or **19***b* within the front passageway **26** and the illumination device passageway **27** by pulling the circulating gas into an intake side of the closed loop fan unit **20**, and generating the flow **19***c* within the rear passageway **21** by pushing the circulating gas out an exhaust side of the closed loop fan unit **20**. Because the intake, relatively low-pressure side, of the closed loop fan units **20** is fluidly adjacent to the front passageway **26** and/or the illumination device passageway **27**, the pressure of the flows **19***a* and/or **19***b*, particularly near the exit of the front passageway **26** and/or the illumination device passageway **27**, may be maintained at a relatively low level, such as negative relative to pressure of ambient air outside of the units **10**, though such is not necessarily required.

Alternatively, without limitation, the one or more of the closed loop fan units **20** may be positioned at a portion of the rear passageway **21** adjacent to an entrance into one or both of the front passageway **26** and the illumination device passageway **27** for generating the flows **19***a* and/or **19***b* through the front passageway **26** and the illumination device passageway **27** by pushing the circulating gas through the front passageway **26** and the illumination device passageway **27**. Because the exhaust, relatively high-pressure side of the closed loop fan units **20** is fluidly adjacent to the front passageway **26** and/or the illumination device passageway **27**, the pressure of the flows **19***a* and/or **19***b*, particularly at the entrances to the front passageway **26** and the illumination device passageway **27**, may be maintained at a relatively high level, such as greater than pressure of ambient air outside of the units **10**, though such is not necessarily required.

The front passageway **26** and/or the rear passageway **21** may be configured to create and maintain a pressure differential between the flows **19***a* and **19***b* of the circulating gas in the front passageway **26** and/or the rear passageway **21** sufficient to generate net forces at the electronic display layers **13** which reduces or eliminates bowing of the electronic display layers **13**. In exemplary embodiments, the pressure of the flow **19***a* in the front passageway **26** may be maintained at a higher level than the flow **19***b* in the illumination device passageway **27**, resulting in rearward forces against the electronic display layer **13** to reduce or eliminate outward bowing. Such pressure differentials may be generated using features including, but not limited to, those shown and/or described in U.S. Pat. No. 10,398,066 issued Aug. 27, 2019, the disclosures of which are hereby incorporated by reference as if fully restated herein.

In exemplary embodiments, without limitation, one or more intake openings **53***a*, **53***b* into the illumination device passageway **27** from the rear passageway **21** may be larger than one or more exit openings **55***a*, **55***b* from the illumination device passageway **27** to the rear passageway **21**. In this manner, more circulating gas may be ingested into the illumination device passageway **27** than is readily able to exit, thereby raising average pressure in the illumination device passageway **27**.

As shown with particular regard to FIGS. **3**A**1**-**3**A**5**, the electronic display layer **13** may be held in place by one or more brackets **51***a*, **51***b*. The brackets **51** may define, at least in part, the one or more intake openings **53***a*, **53***b* and/or the one or more exit openings **55***a*, **55***b*. At least some of the brackets **51** may comprise protrusions **57** configured to maintain relatively spacing for the intake openings **53** and/or the exit openings **55**.

One or more of the closed loop fan units **20** may be provided wholly or partially within one or more housings **59**. The housings **59** may be configured to direct circulating gas in an appropriate direction, such as between the front passageway **26** and/or the illumination device passageway **27** into the rear passageway **21**, or vice versa.

One ore more gaskets **61** may be provided at the housing **59**. For example, without limitation, the gaskets **61** may be provided to fully or partially seal the housings **59** against a panel **63**. In this fashion, the closed loop fan units **20** may be fully or partially sealed against the panel **63** so as to increase the amount of air forced into the front passageway **26** and/or the illumination device passageway **27**, such as from the rear passageway **21**, and/or out of the front passageway **26** and/or the illumination device passageway **27**, such as from the rear passageway **21**. The gaskets **61** may, alternatively or additionally, provide vibrational damping and/or sound reduction, such as during operating of the closed loop fan units **20**. The gaskets **61** may comprise rubber and/or a rubber composite, by way of non-limiting example.

The panel **63** may from part of the open loop airflow pathway **23**. For example, without limitation, the panel **63** and an additional panel **65** may be provided spaced apart from one another, such as with the corrugated layer **25** therebetween, to at least partially define the open loop airflow pathway **23**.

In exemplary embodiments, positive pressure may be maintained in only the front passageway **26** and/or relatively high pressure may be maintained in the front passageway **26** (e.g., relative to pressure in the flow **19***b* in the illumination device passageway **27**) such that the electronic display layer **13** is pushed towards the illumination device **15** when the closed loop fan unit **20** is operated. Optical spikes **29** or other support structures may be utilized within the illumination device passageway **27** to reduce or eliminate movement of the electronic display layer **13** towards the illumination device **15**, such as past the optical spikes **29**. The optical spikes **29** may comprise one or more optically transmissible materials. The optical spikes **29** may comprise rods, cones, or the like positioned within the illumination device cavity **27** and may be configured to limit or prevent rearward travel of the electronic display layer **13**. The optical spikes **29** may exert normal, compressive forces on the electronic display layer **13**, particularly in conjunction with the pressure of the flow **19***a* of the circulating gas within the front passageway **26**. This may be particularly beneficial when unable to generate positive or sufficiently high pressure for the flow **19***b* of the circulating gas within the illumination device passageway **27**. This may occur, for example, without limitation, due to variations in ambient air and/or circulating gas pressure. Circulating gas pressure, in particular, may vary due to temperature variations in the

circulating gas (e.g., due to solar loading) and/or ambient temperatures, which may affect the unit's **10** ability to remove heat in air-to-air heat exchange.

In exemplary embodiments, the pressure of the circulating gas in the front passageway **26** and the illumination device passageway **27** may be regularly, sporadically, and/or continuously monitored and operations may be adjusted based on such measurements. Such operations may include the speed or other operation of the closed loop fans **20**. Such operations may be adjusted to desired pressures in the front passageway **26** and the illumination device passageway **27**, such as positive pressures in one or both, and/or desired differential pressure between the same.

Any number, type, kind, and/or arrangement of such optical spikes **29** may be utilized. In embodiments where more than one electronic display layer **13***a*, **13***b* is utilized, more than one set of optical spikes **29***a*, **29***b* for each respective one of the electronic display layers **13***a*, **13***b* of the same or different type may likewise be utilized, though such is not required. Such optical spikes **29** are not necessarily required, and may be omitted from view of certain embodiments provided herein to more clearly illustrate other components. However, such optical spikes **29** may be utilized in the same or similar arrangements in such embodiments, even if not expressly provided in the figures.

Any embodiment of the present invention may include any of the features of the other embodiments of the present invention. The exemplary embodiments herein disclosed are not intended to be exhaustive or to unnecessarily limit the scope of the invention. The exemplary embodiments were chosen and described in order to explain the principles of the present invention so that others skilled in the art may practice the invention. Having shown and described exemplary embodiments of the present invention, those skilled in the art will realize that many variations and modifications may be made to the described invention. Many of those variations and modifications will provide the same result and fall within the spirit of the claimed invention. It is the intention, therefore, to limit the invention only as indicated by the scope of the claims.

Certain operations described herein may be performed by one or more electronic devices. Each electronic device may comprise one or more processors, electronic storage devices, executable software instructions, and the like configured to perform the operations described herein. The electronic devices may be general purpose computers or specialized computing devices. The electronic devices may comprise personal computers, smartphone, tablets, databases, servers, or the like. The electronic connections and transmissions described herein may be accomplished by wired or wireless means. The computerized hardware, software, components, systems, steps, methods, and/or processes described herein may serve to improve the speed of the computerized hardware, software, systems, steps, methods, and/or processes described herein.

What is claimed is:

1. A display assembly for providing compressive forces at an electronic display layer, said display assembly comprising:

a structural framework for said electronic display layer, said structural framework comprising a rear portion;

a cover provided forward of said electronic display layer;

an illumination device provided rearward of said electronic display layer;

a front passageway between a rear surface of said cover and a forward surface of said electronic display layer, each of said front passageway and said illumination device having an entrance;

an illumination device passageway between a rear surface of said electronic display layer and a front surface of said illumination device;

a rear passageway between a rear portion of said structural framework and a rear surface of said illumination device, wherein said rear passageway is fluidly connected to said front passageway and said illumination device passageway; and

a closed loop fan unit positioned adjacent to the entrance to said front passageway and said illumination device passageway, wherein said closed loop fan unit is configured to create a first flow of circulating gas through said front passageway and a second flow of said circulating gas through said illumination device passageway when activated.

2. The display assembly of claim **1** wherein:

said closed loop fan unit is configured to push said circulating gas through said front passageway and said illumination device passageway when activated.

3. The display assembly of claim **1** wherein:

said closed loop fan unit is oriented to provide a relatively high-pressure side facing said entrance to said front passageway and said entrance to said illumination device passageway.

4. The display assembly of claim **1** further comprising:

a closed loop airflow pathway comprising said front passageway, said illumination device passageway, and said rear passageway, wherein said closed loop airflow pathway encircles said electronic display layer.

5. The display assembly of claim **4** further comprising:

an open loop airflow pathway for ambient air; and

an open loop fan unit configured to force said ambient air through said open loop airflow pathway when activated.

6. The display assembly of claim **5** wherein:

said open loop airflow pathway extends rearward of said illumination device.

7. The display assembly of claim **5** wherein:

said closed loop airflow pathway and said open loop airflow pathway are configured to maintain separation between said circulating gas in said closed loop airflow pathway and said ambient air in said open loop airflow pathway.

8. The display assembly of claim **1** wherein:

said closed loop fan unit comprises a housing, a fan positioned within said housing, and at least one gasket provided at said housing to at least partially seal said housing with respect to said entrance to said front passageway and said illumination device passageway.

9. The display assembly of claim **1** wherein:

said electronic display layer comprises a layer of liquid crystals; and

said illumination device comprises a substrate and a number of LEDs provided at said substrate.

10. The display assembly of claim **1** wherein:

said closed loop fan unit is configured to pull said circulating gas through said front passageway and said illumination device passageway when activated.

11. The display assembly of claim **1** wherein:

said closed loop fan unit is oriented to provide a relatively low-pressure side facing said entrance to said front passageway and said entrance to said illumination device passageway.

12. The display assembly of claim 1 wherein:

said closed loop fan unit is configured to cause pressure of said first flow of said circulating gas to be higher than pressure of ambient air outside of said display assembly when activated.

13. The display assembly of claim 12 further comprising:

optical spikes placed within said illumination device passageway for limiting rearward travel of said electronic display layer.

14. The display assembly of claim 12 wherein:

said closed loop fan unit is configured to cause pressure of said second flow of said circulating gas to be higher than pressure of ambient air outside of said display assembly by a lesser amount than said pressure of said first flow of said circulating gas when activated.

15. The display assembly of claim 14 further comprising:

a differential pressure sensor configured to measure the pressure of the ambient air outside of the display assembly and the pressure of the circulating gas in at least one of the front passageway and the illumination device passageway.

16. The display assembly of claim 15 further comprising:

a controller in electronic communication with said differential pressure sensor and said closed loop fan unit configured to adjust operations of said closed loop fan unit in response to measurements from said differential pressure sensor.

17. The display assembly of claim 1 wherein:

said closed loop fan unit is configured to cause pressure of said first flow of said circulating gas to be lower than pressure of ambient air outside of said display assembly when activated.

18. The display assembly of claim 1 wherein:

said closed loop fan unit comprises centrifugal fans.

19. The display assembly of claim 1 wherein:

said closed loop fan unit comprises multiple fans.

20. A method for providing compressive forces at an electronic display layer, said method comprising the steps of:

pushing a first flow of circulating gas through a front passageway between a cover positioned forward of said electronic display layer and a forward surface of said electronic display layer;

pushing a second flow of said circulating gas through an illumination device passageway between an illumination device positioned rearward of said electronic display layer and a rear surface of said electronic display layer; and

pulling a combined flow of said circulating gas comprising said first flow and said second flow of said circulating gas through a rear passageway located between said illumination device and a rear portion of a structural framework for said electronic display layer;

wherein said pushing and pulling steps are performed by a closed loop fan unit positioned adjacent to entrances to said front passageway and illumination device passageway.

21. The method of claim 20 further comprising the steps of:

maintaining at least the first flow of said circulating gas at a pressure higher than a pressure of ambient air; and

providing optical spikes between said illumination device and said electronic display layer to limit rearward movement of said electronic display layer.

22. A double-sided display assembly for providing compressive forces at electronic display layers, said double-sided display assembly comprising:

a structural framework for said electronic display layers;

covers provided forward of each respective one of said electronic display layers;

illumination devices provided rearward of each respective one of said electronic display layers;

front passageways located between a rear surface of each respective one of said covers and a forward surface of each respective one of said electronic display layers;

illumination device passageways located between rear surfaces of each respective one of said electronic display layers and front surfaces of each respective one of said illumination devices;

optical spikes provided within the illumination device passageways;

a common rear passageway between said electronic display layers and configured to accept circulating gas from said front passageway and said illumination device passageways; and

a closed loop fan unit positioned adjacent to entrances to each respective one of said front passageways and said illumination device passageways, said closed loop fan unit comprising a housing, a fan positioned within said housing, and at least one gasket provided at said housing, wherein said closed loop fan unit is configured to create flows of circulating gas through each respective one of said front passageways and flows of said circulating gas through each respective one of said illumination device passageways when activated.

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